



AN EXPERIMENTAL STUDY OF WELDING PARAMETERS FOR STELLITE6 OVERLAY ON INCONEL825 USING PTAW PROCESS

P. Elango

PG Scholar, Department of Mechanical Engineering, Bharath University, Chennai, India.

Dr. P. Sengottuvel

Professor and HOD, Department of Mechatronics, Bharath University, Chennai, India.

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ABSTRACT

Hard facing is a common method for improving the surface properties of components in terms of hardness, wear, corrosion and heat resistance under high pressure and high temperature conditions. Weld overlay is one of the methods to improve the surface properties, quality of weld overlaid components depends on the welding process and parameter. Therefore, it is important to optimize parameters for welding process, in this the most critical element to control is the Fe content in the weld overlay and it is observed that the corrosion properties are not affected when the Fe content is restricted below 5%. The effort is made in this study to apply the stellite6 weld overlay using Plasma transferred arc welding (PTAW) on inconel825 plate with less than 5%(wt) Fe(iron) on the weld material. The result shows that the parameter used in this study, controls the Fe element to 4.49 % (wt) and various properties such as chemical composition, cracking tendencies, hardness across the weld overlay area.

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INTRODUCTION

Weld overlay of hard facing is a common method for improving the surface properties of components. It is used in terms of Hardness, wear, corrosion^[2] and heat resistance under high pressure and high temperature conditions^[2]. The quality of weld overlaid components depends on the weld chemistry which in turn depends on the welding process and parameters. Therefore, it is important to optimize parameters. In welding process, the dilution^[1] plays the major role to get the correct chemistry and hardness^[4] to meet the standard requirements. The effort is made in this study to apply the weld overlay using

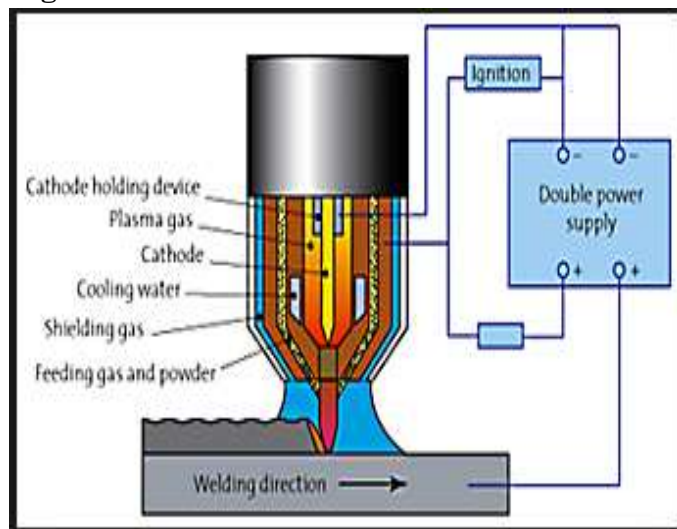
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PTAW (Plasma Transferred Arc Welding) on inconel825 plate. The stellite6 materials resist oxidation and have good anti-galling properties. If the Cobalt and chromium properties is not within the limits on the weld overlaid material, then hardness and corrosion resistance properties will not meet their functions, stellite6 are weld overlaid on valves component such as Seat rings as shown in Fig. 2 and disc etc.

Welding generally involves joining of metals by applying heat for melting of metals to be joined. The arc welding processes offer high heat input^[7] which leads to various problems such as blow holes, deformation and porosity. The selection of correct welding process parameters, procedure and technique are essential to eliminate the above problems. The Plasma Transferred Arc Welding (PTAW) processes consist of non-consumable tungsten electrode fixed inside the torch, a water-cooled constrictor nozzle, plasma gas (center gas) and shield gas protecting molten metal from forming any defects.

In PTAW, powder form of consumable is used. In PTAW process, volume of weld overlay is higher than the gas tungsten welding. The PTAW machine consists of welding boom, torch, power source, pilot arc machine and welding table. The PTAW process can be used for limited applications as compared to the GMAW as it requires more machinery, table etc., and involves cumbersome job set up. The PTAW model is described in Fig. 1.

Figure 1: PTAW Model



Stellite6 alloys are cobalt based alloys^[1]. When they are overlaid on the inconel825 material with a help of welding, there is possibility intermixing of both the material. It causes the higher iron content in the overlay on the first layer. It leads to decreases the corrosion resistance of the Stellite6 alloy in extreme corrosion environments, because the Cr content and Fe content drops. Also it decreases the overall carbon content and it affects the wear resistance and hardness.

Figure 2: Seat Ring Hard Faced and Machined



For this PTAW process there are few major control parameters^[4] such as current, powder speed, gas flow rate, number of layers, heat input, weld bead and nozzle to work distance to control the dilution. In this process the shielding gas used is Argon for better shielding to avoid the oxidation and defects porosity, inclusion etc.

EXPERIMENTAL SETUP

2.1 Process

Experiments are conducted using the PTAW process at RSL Alloy Coating (P) Ltd., Chennai. The PTA machine consists of Boom, Plasma torch, power source, welding table and Pilot arc machine. Industrial pure and commercial grade Argon gases were used for shielding, powder feeding and center (Plasma). The welding torch uses the non-consumable tungsten rod with diameter 4mm with 2 % Thorium.

Figure 3: PTAW Machine



The base material used is Inconel825 plate and the size of the plate is 150 mm x 150 mm x 25 mm thick. The base material was machined to above size and wet type liquid penetration exam was conducted to remove the dust, grease or oil to ensure clean material. The PTAW weld was performed on below the machine as shown in Fig. 3.

The base material used was inconel825 and the weld overlay was stellite6 (ERCoCr-A). The effect of weld quality is studied with reference to input parameters like current, height of the torch tip to the base metal, number of layers, powder feed rate and heat input. The chemical composition for Inconel825 (UNS N08825) base material as per ASTM B424^[5] Code is listed in Table I.

Table I

Elements	% max
C	0.05
Ni	38-46
Cr	19.5-23.5
Fe	22
Mn	1
Cu	0.05
Si	0.5
S	0.03
Al	0.2
Ti	0.6-1.2

The chemical composition for consumable-ErCoCr-A (stellite6) as per ASME Sec II Part C SFA 5.21-2011a (chemical only) is described in Table II.

Table II

Elements	% max
C	0.9-1.4
Mn	1
Si	2
Cr	26-32
Ni	3
Mo	1
Fe	3
W	3-6
Co	Balance
Others	0.5

The Stellite6 welding was carried out considering the following input parameters. The values of weld parameters are optimized after conducting several of trial experiments. The optimized parameters and their values are described in the Table III.

Table III

Parameter	Value
Power Source	400 Amp- IGBT machine
Type & Polarity	DC SP
Mode of operation	Automatic
Particle size	70-325 mesh
Shielding gas	Argon
Shielding gas flow rate	12 LPM
Powder Gas	2 LPM
Tungsten rod	4mm Dia (EWTH2)
Center gas	4LPM
Contact tube to work distance	15mm
Thickness of base material	20 mm
Weld metal Thickness	1.6 mm per layer
No of layers	2
Amperes	165 A
Voltage	18 V
Travel speed	165mm/ min
Heat Input	1.188 KJ/mm
Bead	Weave- 16 mm
Overlap	1/3 rd
Orifice to gas cup size	35 mm
Interpass Temp	Less than 350 Deg C

2.2 Weld Overlay Layout

Two layers of weld overlay were done on the Inconel825 thick plate. The first layer height was 1.6 mm layer and the total weld height was 3 mm after the two layers of weld as per the figure 3. The weld area was 150 mm length and width was 40mm, the weld was performed as per the measurements shown in Fig. 4 and Fig. 5.

Figure 4: Weld Layer

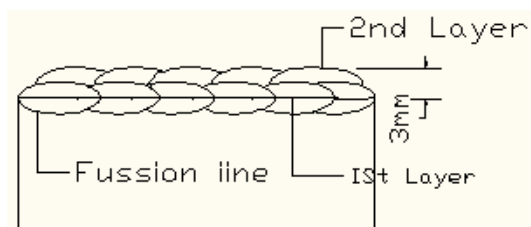
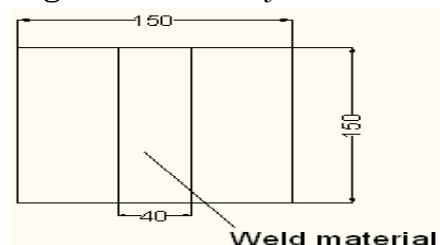


Figure 5: Weld Layout



MEASUREMENT OF OUTPUT

3.1 Chemical analysis

Table IV shows the recorded chemical analysis result of weld metal after machining to 1.6 mm. The comparison is done between the specification standards of the consumable and welded material. The Fig. 6 shows that the Fe% is above 3% and below 5%. This proves the effectiveness of the parameters used in this study. Fig. 10 shows, even though the base material has 22 % (wt) of Fe, the weld material has less than 5% indicating lesser dilution level in the weld material

Figure 6

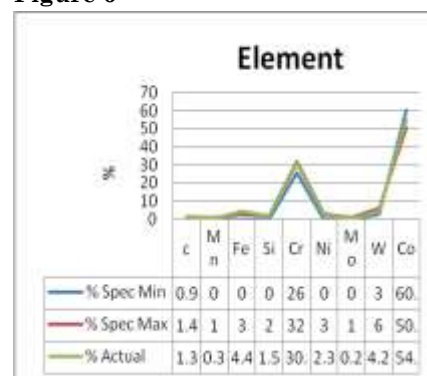


Table-IV

Elements	% Spec	% Actual
C	0.9-1.4	1.38
Mn	1	0.34
Fe	3	4.49
Si	2	1.5
Cr	26-32	30.6
Ni	3	2.37
Mo	1	0.22
W	3.0-6.0	4.21
Co	Balance	Bal

3.2 Hardness Analysis

Vickers's hardness^[3] testing machine was used to measure the hardness of the weld metal with a 10 Kg load. The hardness survey conducted various positions as per the Fig. 7. In each location hardness survey conducted at 3 points and the hardness meets with the NACE MR0175/15156-2009. The survey conducted on the location as per the Fig. 7 and the results are presented in Table V.

Figure 7: Survey Location

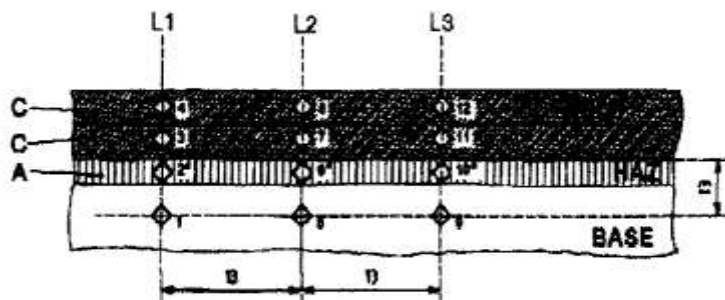


Table V

Position	Indent location	Hardness value L1	Hardness value L2	Hardness value L3	Avg. HV
Overlay Top	4,8,12	339	342	339	340
Overlay surface (Mid cross section)	3,7,11	322	330	330	327.3
Base	1,5,9	192	191	189	190.6
HAZ (0.5 mm from fusion zone)	2,6,10	264	270	266	266.7

From Fig. 8, it is clearly shows that the hardness values of the weld top is better than parent metal indicating higher strength of the weld overlay.

Figure 8: Hardness Survey

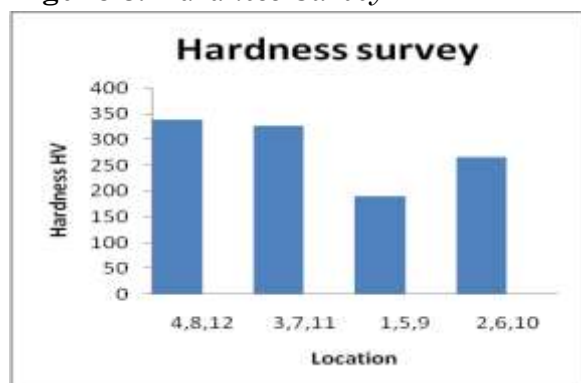
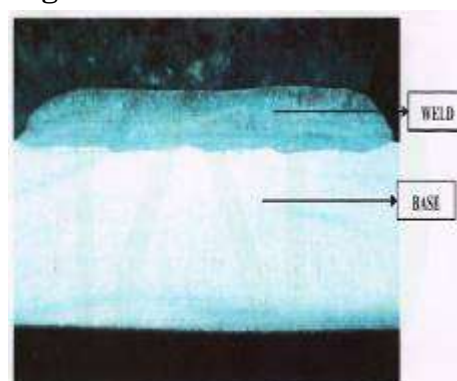


Figure 9: Macro Examination Weld Metal



3.3 Macro Structure Examination

Macro examination conducted on the specimen by using 10 x magnifications is referred in Fig. 9. The sample was macro etched and examined visually followed by microscopic magnification of 10x. The figure shows complete fusion between weld and base metal and there are no cracks founds.

3.4 Liquid Penetration Examination

Liquid penetration examination conducted on the specimen with the following steps as per ASME Sec V^[6] and accepted procedure as per.^{[8][9]}

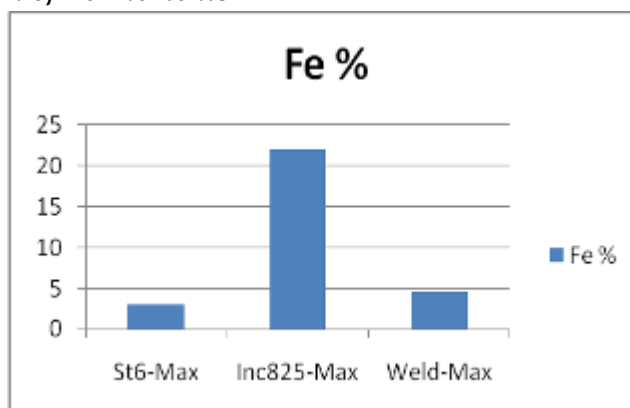
First, the surface area was cleaned with the help of a cleaner and wiped with clean cloth to ensure dust and grease free surface. During testing the material temperature was maintained below 50 Deg C^[6] and penetrant was applied with a help of soft brush giving a dwell time of 10 min^[6]. After that it was cleaned using the cleaner with cloth followed by

application of developer using spray method. The material was then examined with 1000 lux lighting. The result showed that there was no indication and it was accepted. The chemical used for the Liquid penetration examination is listed in table VI.

Table VI

Name Of Chemical	Batch No	Make	Penetration Time
Cleaner	14D01	Magnaflux	-----
DYE Penetrant	13A12	Magnaflux	20 Minutes
Developer	13K91	Magnaflux	-----

Figure 10: Comparison of Fe Elements



CONCLUSION

The following conclusion observed from the above experiments.

1. Various properties of Stellite6 (ERCrCo-A) weld overlay on Inconel825 material using PTAW process are studied. The study reveals that the good overlay is obtained below 5% Fe with appropriate values of process variables that includes 165 Ampere, 165 mm/minute travel speed. It shows that the welded material meets the requirements of hardness and the corrosion properties for the studied parameters.
2. The carbon and chromium content of weld overlay reached to maximum that shows that the hardness and wear resistance of the weld material have improved.
3. The hardness values of the weld material is more than the base material of Inconel825. This shows better strength of the weld overlay and resistance to corrosion. The macrostructure of the weld joint indicates that there is good fusion between base material and weld overlay and it is free from defects.
4. Future work may be done to reduce Fe level below 3% to accomplish further improvement. Research on this may be carried out by increasing the weld height above 3mm as number layer is expected to reduce the dilution.

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